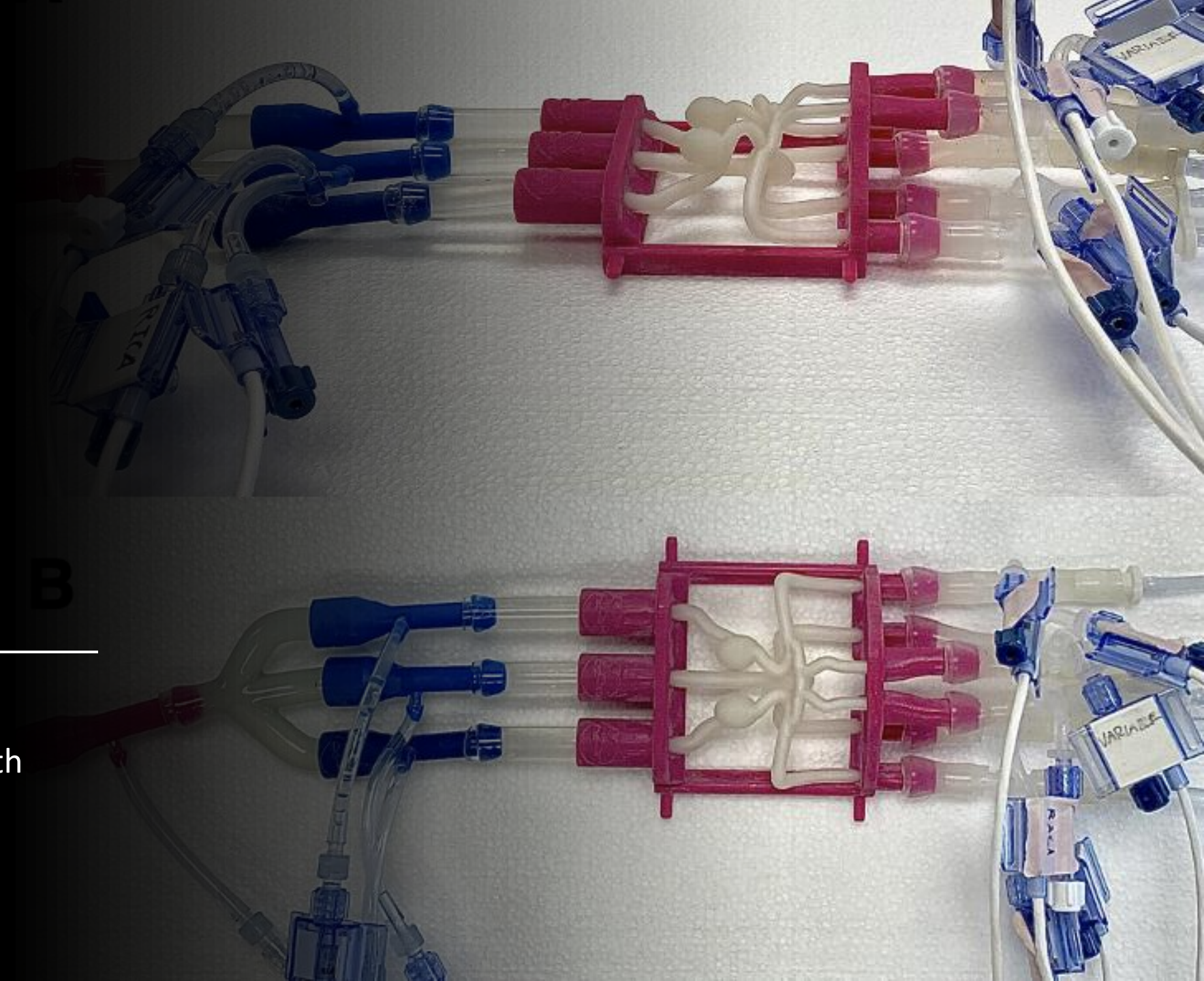
BDL/Aneuvas

Kathryn Nelson - Luke Nelson -
Aditya Ponugupaty - Isaac Smith

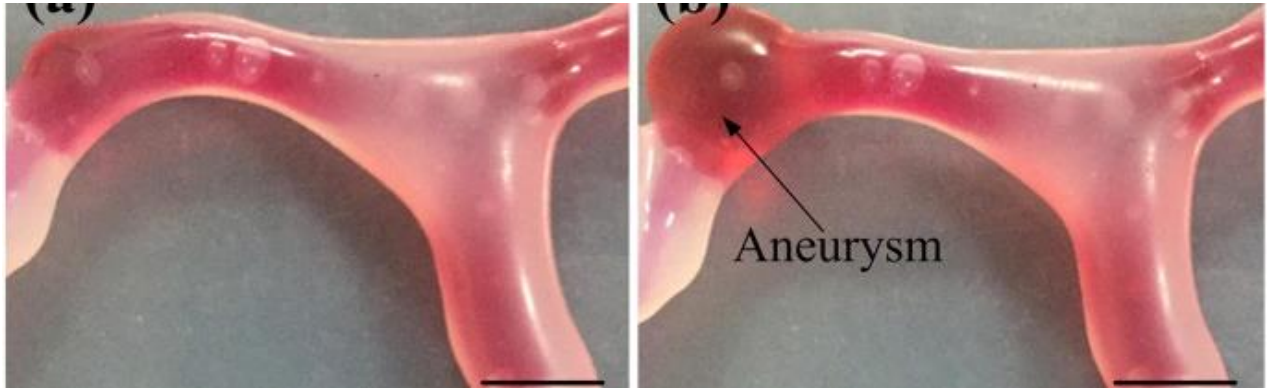


Project Description

Team BDL/Aneuvas is tasked with:

- Creating a 3D printed model that replicates organic tissue measurable to the human carotid artery.
- To analyze, design, 3D-print and test "plug and play" models of blood vessels in the brain, such as aneurysms, using innovative layering methods.
- Provide the client with qualitative data on material properties for each method.

[1]



Sponsor(s) and Importance

Sponsors:

- Dr. Becker (BDL)
- Aneuvas Inc.

Stakeholders:

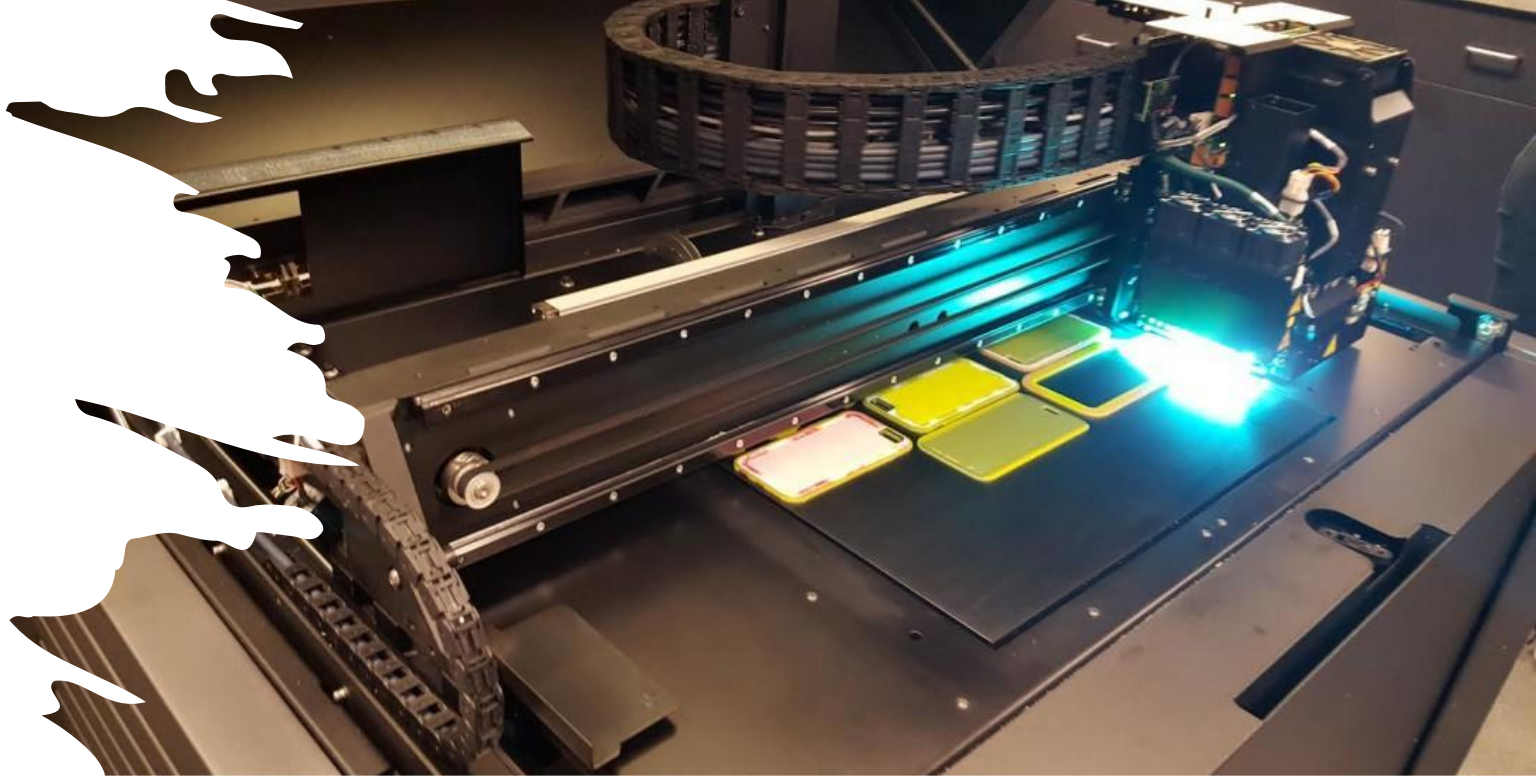
- Material engineers
- Model Developers
- Neurosurgeons

[2]

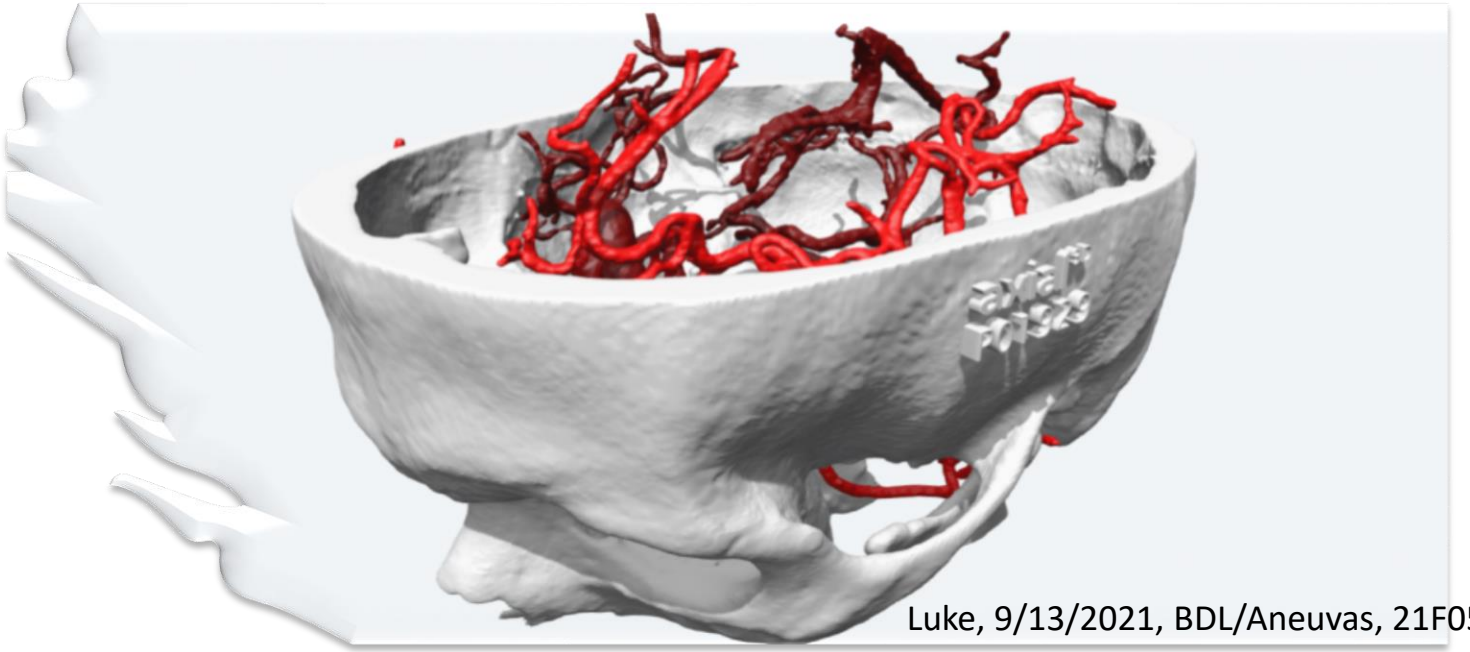
Background & Benchmarking

- Bioengineering Devices Lab (BDL) provides opportunities in neurovascular devices [4]
  - New microcatheter designs
  - Ischemic stroke systems
  - Innovative embolic agents for aneurysms
- Biomodics (Denmark) [5]
  - Aim is to eliminate medical device complications
  - Holds the patent portfolio for supercritical CO2, interpenetrating polymer networks and drug delivery

- Stratasys [6]
  - Large 3D printer manufacturer
  - Works alongside Ford Motors
  - At the forefront of the 3D printing world



- Axial 3D [8]
  - Makes patient specific surgery routine
  - Automatically converts all 2D imaging into clinically relevant 3D images and prints.



Importance

Statistical importance:

- Estimated 6.5 million people in U.S. have an unruptured aneurysm, or 1 in 50 people [3].
- 500,000 deaths worldwide per year. Half of the victims are younger than 50 [3].

Model importance:

- Creating a more property accurate model of brain vessels can assist:
  - Medical students [9]
  - Neurosurgeons
  - Bio-Engineers
  - Researchers
- Allows for neurosurgeons to practice before preforming the operation which leads to:
  - More clear direction of the veins [9]
  - Less mistakes during surgery [9]
  - Increases the safety of the patient [10]
  - Cheaper costs for the patient [10]

Literature Review

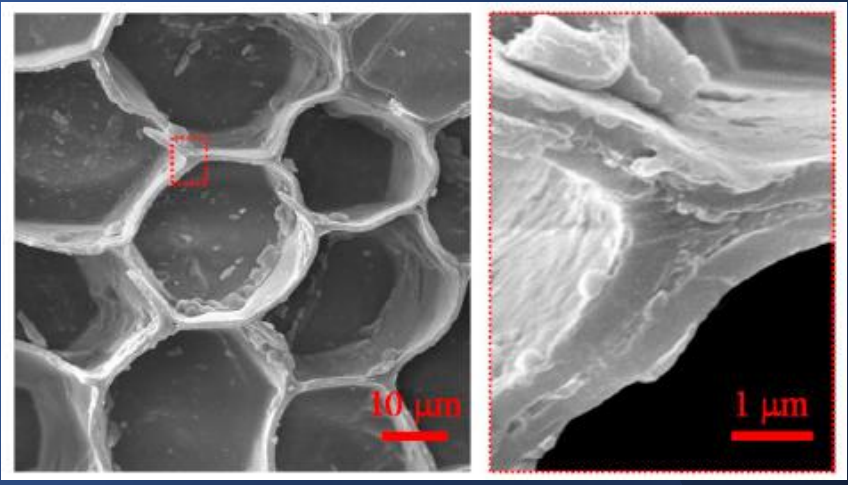
3D printing methods: (Kathryn)

- Fused Disposition Modeling (FDM) printers, print layer by layer, most common [11]
  - Uses thermoplastics or biomaterials to print layers as thin as 10-200 µm, in order to replicate the properties of vessels [12]
- 3D printing patient specific models based off 2D imaging [10]
  - Takes a CT scan of the patient's brain to gain a clear visual of the aneurysm and the veins surrounding it

Behavior under testing: (AP)

- Experimental challenges of shear rheology: how to avoid bad data [13]

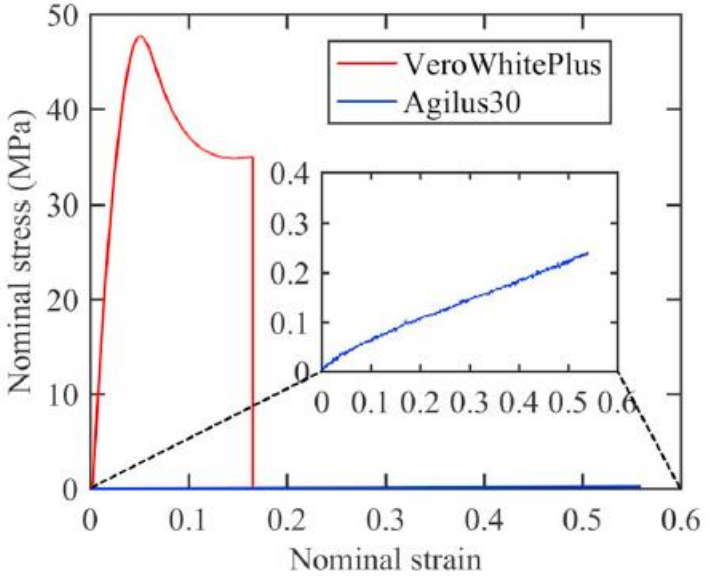
  To make sure we are collecting accurate data, we need to look at discrepancies' that yield bad data.



Literature Review

- Hardness and Lubricity (Isaac)
  - Hardness: Durometer used to test sample hardness vs. Using a rheometer with a spherical indenter. Larger scaled 3D prints.[14]
  - Hardness and lubricity tests were determined to be destructive tests for the samples. Lubricity performed through a sample soaked in PBS and measuring rheometer friction of sample. [15]

- Stress/Strain Analysis (Luke)
  - VeroWhitePlus (VW) vs Agilus 30 [16]
    - VW yields at a ~5% strain and abruptly fails around 16% of tensile strain.
    - Agilus30 displays rubber-like hyper-elastic behavior and provides remarkable elasticity and shape recovery.
    - VW is much more brittle.



Client Requirements & Engineering Requirements

Tests Conducting	Client Requirements	Engineering Requirements
Elastic and Shear Moduli	Size	Stiffness / E (kPa)
Tensile Modulus	Easy to Connect	Thickness (um)
Poison's Ratio	Soft interior, hard exterior (Layered)	Compressive modulus (kPa)
Hardness	Lightweight	Frequency (rad/s) (up and down)
Radial Force	Material Selection	Poison's Ratio
Compliance	Retains shape	Compliance (cm^3/mmHg)
Lubricity	Similar properties to organic tissue	Angular Acceleration (rad/s)
-	-	Radial Force (N/mm)
-	-	Pressure (mmHg)

**Table values do not correlate from left to right. Only for information display.*

House of Quality

Project:	3D Printing and Testing
Date:	Fall '21 - Spring '22
Names:	
Kathryn Nelson	
Luke Nelson	
Aditya P.	
Isaac Smith	

Direction of Improvement	
Maximize	▲
Target	▫
Minimize	▼

Relationships		Weight
Strong	●	9
Medium	▫	3
Weak	▽	1

Correlations	
Positive	+
Negative	-
No Correlation	

ustomer Competitive Assessmer	
1	Poor
3	Acceptable
5	Excellent

		Stiffness/ E (kPa)	Thickness (mm)	Compressive Modules (kPa)	Frequency (rad/s)	Poisson's ratio (unitless)	Compliance (cm^3/mmHg)	Angular Acceleration (rad/s)	Radial Force (N/mm)	Layering (um)	Pressure (mmHg)	Benchmark Assessment			
		Direction of Improvement	▼	▼	▲	▫	▫	▲	▫	▫	▲	▫				
Relative Weight	Customer Importance	Customer Requirements	Engineering Requirements										BDL	Biomotics	Stratasys	Axial3D
3%	1	Size	●	●	▽	▫	▫	●	▽	▽	▫	▽	5	3	5	3
9%	3	Easy to connect	▽	●	▽	▽	▽	▽	▽	▽	▫	▽	5	3	3	5
26%	9	Soft interior, hard exterior (layered)	●	▽	●	▽	▽	▫	▫	▫	●	●	3	5	1	1
3%	1	Lightweight	●	▫	▫	▽	▫	▽	▽	▽	▫	▫	3	3	3	3
26%	9	Material selection	●	▽	●	●	▫	●	●	●	●	●	5	3	5	3
9%	3	Retains shape	▫	▫	▽	●	●	▫	▫	▽	●	▫	3	3	3	5
26%	9	Similar properties to organic tissue	●	▫	●	●	●	●	▫	▫	●	●	5	1	3	1
		Importance Rating Sum (Importance x Relationship)	780	266	722.8571	586	437.1	602.8571429	425.7142857	408.6	814.286	740				
		Relative Weight	13%	5%	13%	10%	8%	10%	7%	7%	14%	13%				
		Technical Requirment Units	kPa	mm	kPa	rads/s		cm^3/mmHg	rads/s	N/mm	um	mmHg				

Schedule

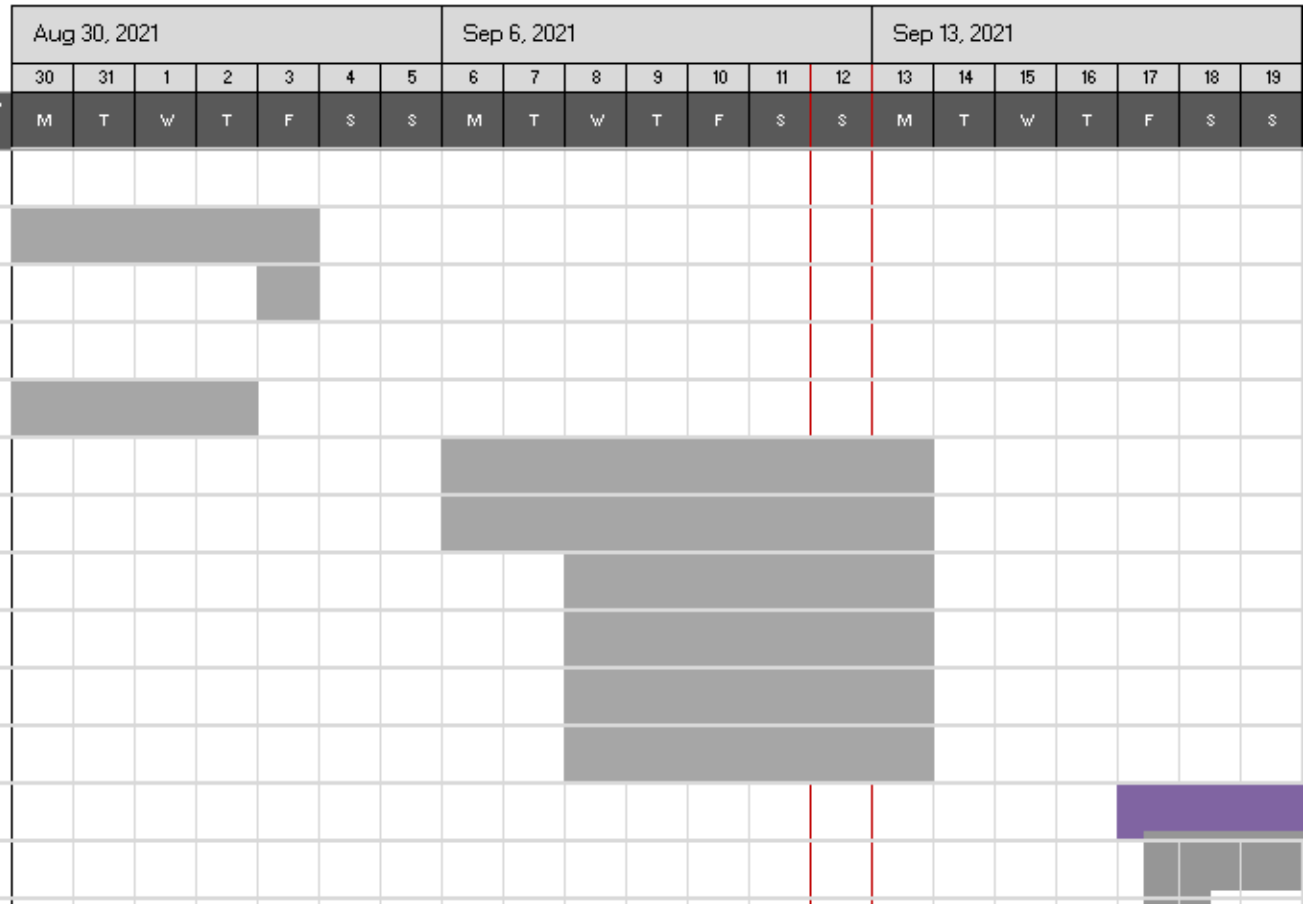
BDL/ANEUVAS CAPSTONE

NAU ME Capstone
Project Lead: Isaac Smith

Project Start: Mon, 8/30/2021
Display Week: 1

** As of date of making

TASK	ASSIGNED TO	PROGRESS	START	END	DAYS
Introduction					
Team Charter and MS Team setup	All	100%	8/30/2021	9/3/2021	5
Meet with client	All	100%	9/3/2021	9/3/2021	1
Customer and Engineering Reuqirements					
Read Nick's paper	All	100%	8/30/21	9/2/21	4
Presentation 1	All	100%	9/6/21	9/13/21	8
Project Description and Benchmarki	All	100%	9/6/21	9/13/21	
House of Quality	Issac	100%	9/8/21	9/13/21	
Schedule	AP, Luke	100%	9/8/21	9/13/21	
Literature Review	All	100%	9/8/21	9/13/21	
Budget	Kateryn	100%	9/8/21	9/13/21	
Website Creation/Work	Luke	0%	9/17/21	9/22/21	6
Preliminary Report Start	All	0%	9/21/21	9/21/21	1



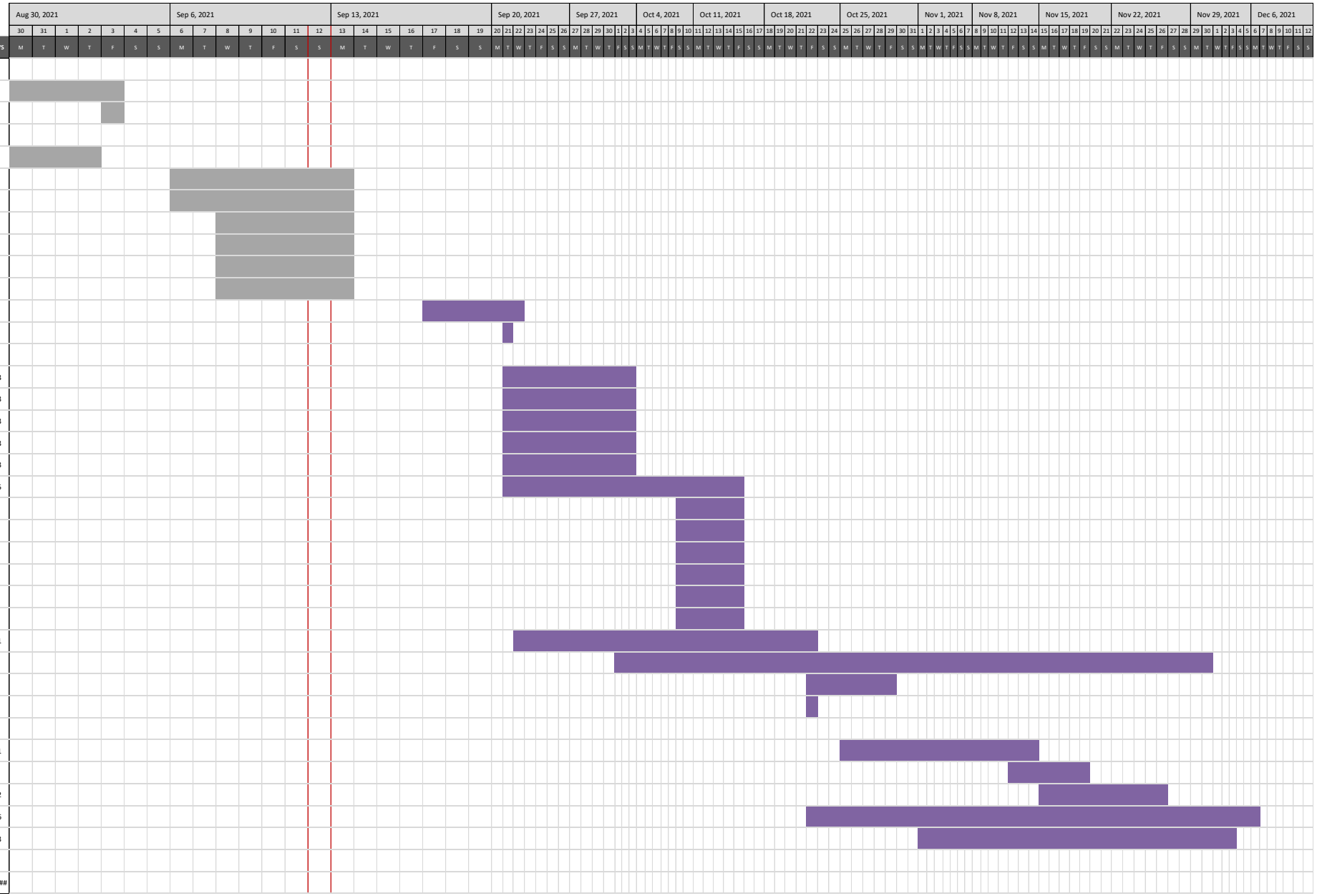
BDL/ANEUVAS CAPSTONE

NAU ME Capstone
Project Lead: Isaac Smith

Project Start: Mon, 8/30/2021
Display Week: 1

** As of date of making

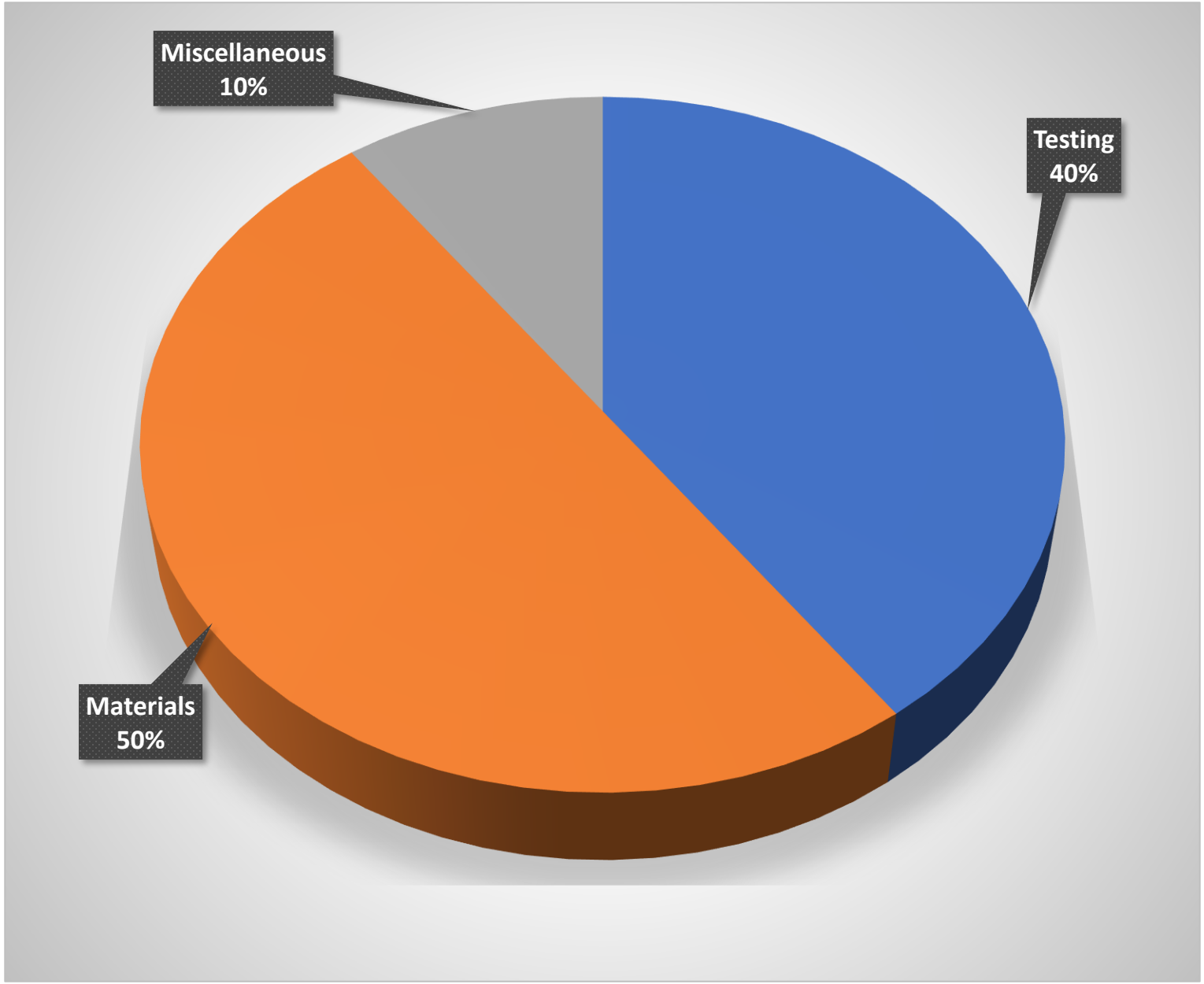
TASK	ASSIGNED TO	PROGRESS	START	END	DAYS
Introduction					
Team Charter and MS Team setup	All	100%	8/30/2021	9/3/2021	5
Meet with client	All	100%	9/3/2021	9/3/2021	1
Customer and Engineering Reuqirements					
Read Nick's paper	All	100%	8/30/21	9/2/21	4
Presentation 1	All	100%	9/6/21	9/13/21	8
Project Description and Benchmarking	All	100%	9/6/21	9/13/21	
House of Quality	Issac	100%	9/8/21	9/13/21	
Schedule	AP, Luke	100%	9/8/21	9/13/21	
Literature Review	All	100%	9/8/21	9/13/21	
Budget	Kateryn	100%	9/8/21	9/13/21	
Website Creation/Work	Luke	0%	9/17/21	9/22/21	6
Preliminary Report Start	All	0%	9/21/21	9/21/21	1
Concept Generation and Evaluation					
Presentation 2	All	0%	9/21/21	10/3/21	13
Project Description	All**	0%	9/21/21	10/3/21	13
Concept Generation	All**	0%	9/21/21	10/3/21	13
Concept Evaluation	All**	0%	9/21/21	10/3/21	13
Budget Planning	All**	0%	9/21/21	10/3/21	13
Preliminary Report	All	0%	9/21/21	10/15/21	25
Background	All**	0%	10/9/21	10/15/21	7
Customer and Engineering Requirements	All**	0%	10/9/21	10/15/21	7
Research	All**	0%	10/9/21	10/15/21	7
Benchmarking and Functional Decomposit	All**	0%	10/9/21	10/15/21	7
Design Selection	All**	0%	10/9/21	10/15/21	7
Concept Generation	All**	0%	10/9/21	10/15/21	7
Website Check 1	Luke	0%	9/22/21	10/22/21	31
Testing Days	AP	0%	10/1/21	11/30/21	
Analytical Analysis Memo	All	0%	10/22/21	10/29/21	8
Final Concept and Design Preperation	All	0%	10/22/21	10/22/21	1
Final Concepts for Semester 1					
Final Concept Report	All	0%	10/25/21	11/14/21	21
Final Bill of Materials and CAD	All**	0%	11/12/21	11/19/21	8
Individual Analytical Analysis	All	0%	11/15/21	11/26/21	12
Website Check 2	Luke	0%	10/22/21	12/6/21	46
Final Prototype	All	0%	11/1/21	12/3/21	33
Semester 2 Start-up					
Review Final Concept Report			date	date	#####



Budget

An estimated overall budget of $1,000
Estimated allocations:

- $500 in materials, measured per grams used.
- $400 of testing time of rheometer, fluoroscope, and lab usage.
- $100 for miscellaneous cost associated with material or small tools.



Resources

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That's all Folks!